ARTÍCULO DE OPINIÓN

THE PARADOX OF THE RICH: ARE THERE TOO MANY INSECT SPECIES IN ECUADOR, OR TOO FEW SCIENTISTS TO STUDY THEM?

The biodiversity conundrum

When Carl von Linné (1737) cited Edward Coke's (1628) dictum "Nomina si nescis, perit et cognitio rerum" (if you do not know the names, the knowledge of things perishes), he not only framed the monumental task of naming and classifying the known plants of his era but underscored the enduring significance of taxonomic nomenclature, a relevance that persists today (3), although not without challenges (4). The Linnean system was virtually accepted by many experts of the epoch (3). Since 1758, the date of publication of the 10th edition of Systema Naturae (5), which marks the inception of the International Code of Zoological Nomenclature, ICZN, about 950,000 insect species have been described (6). With a rate of approximately 7,000 new insect species described per year, the total would round to about 1.06 million species worldwide (7). Tropical America alone harbors a staggering proportion of that diversity, ranging from 3 to 30 million! (8), although the upper figure is probably unrealistic as most recent global assessments suggest ca. 5 to 10 million species (9, 10). This paramount diversity eclipses most other tropical regions in the world (11).

Yet, this conclusion derives from studies of "exemplar" groups of plants and animals, the latter usually vertebrates: typically, mammals, amphibians, reptiles, and birds. As to the invertebrates, two insect groups are accounted for in the majority of global and regional estimates: butterflies [mostly Nymphalidae, for example, the clearwings (12)] and dung beetles [Scarabaeidae, subfamily Scarabaeinae (13)]. Despite their functional and ecological relevance, these groups represent less than 1% of the Neotropics' potential insect richness (based on May's 1990 estimate). What of the remaining ~ 300 families in their respective orders (Lepidoptera and Coleoptera), let alone the other ca. 21 orders? How can science address the other 99% of the insect fauna, most of which remains undiscovered? (14).

In Ecuador, the taxonomic landscape reflects a similar trend, with only a few insect groups being moderately well-studied, particularly those that are visually striking or ecologically conspicuous. Among the Coleoptera, for example, the dung beetles are relatively well-documented with over 200 recorded species (15). Ants and orchid bees have also received attention, especially from the Amazon, and at the present time, about 800 and 115 species are known, respectively (16, 17). The butterflies have also been quite collected and studied. According to Jason Hall, the butterflies of Ecuador would represent about 50% of the Neotropical fauna, but only a small fraction is currently known (18). Despite these efforts, Ecuador's natural history collections, housing millions of specimens collected from virtually all known ecosystems, face critical challenges. Most of the preserved material requires proper taxonomic curation and professional treatment, in addition to improving the physical infrastructure, as well as hiring qualified permanent staff. These factors go hand in hand with limited funding, which is always the first barrier to surpass.

Aside from financial issues, which are usually the norm in developing nations, this underscores the urgent need for motivated, experienced, and early-career taxonomists to unlock this scientific potential by identifying the preserved material. Right now we do not necessarily require "more boots on the ground", as Edward Wilson once put it (19), but rather more hands opening drawers and sorting specimens out from ethanol-filled jars

which have never been examined. In the collections of at least three Ecuadorian institutions: Pontificia Universidad Católica, Escuela Politécnica Nacional, and Instituto Nacional de Biodiversidad, there are enough fogging-collected, canopy samples to fill thousands of drawers with pinned-mounted specimens. An estimated 2.5 million insects, representing 10 orders, have been retrieved out of 1200 canopy samples obtained between 1994 and 1996 from just two sites in Amazonian Ecuador. Most of these samples are now in the Smithsonian Institution in Washington and Escuela Politécnica Nacional. According to Terry Erwin, who was an expert in carabid beetles, from that material alone, there are hundreds of new species of the genus *Agra* Fabricius awaiting description (pers. comm.).

The tiny fraction of the insect species diversity we currently know from Ecuador, maybe less than 1%, undermines conservation efforts, leaving countless species potentially at risk of extinction before they can even be studied or protected. This is called the taxonomic gap (20), also known as the Linnean shortfall (21), and is negatively influencing our ability to understand how the organisms we share the planet with evolve, interact, and are being affected by many factors, including the warming of the Earth. Amid increased extinction rates of the insect fauna globally (22), where the main culprit is human chronic intervention in nature (23), the most probable answer to the question ¿Can we humans name all insect species before it is too late? does not look promising. Some even say this task could take more than 400 years (24). This conundrum is particularly serious in tropical regions where the diversity of wildlife reaches top levels, like in the Western Amazon Basin, mainly Ecuador, Peru, and Colombia (25), and where very little has been done to ameliorate the taxonomic gap (26). Unfortunately, the countries and their administrative institutions, such as the ministries of environment, which are responsible for managing and protecting this biodiversity, are plagued by corruption, which is often fueled by the influence of unethical groups seeking to extract our natural resources despite the opposition of native indigenous peoples (27). Altogether, this continued process resulted in decades of socio-economic instability. This is the classic paradox of abundance, where a few influential groups selfishly deplete the Nation's natural resources in the absence strict regulatory oversight. As a result, this favors both the strategic goals of governments and companies. However, it erodes nature's equilibrium and the socio-economic conditions of most of us who build the society (28).

Are Ecuadorian insect taxonomists in decline?

The service of taxonomy provides a standardized framework for identifying and comparing organisms. By linking species names to ecological functions, we guide conservation efforts and inform ecosystem management. However, the disproportionate imbalance of the vast number of unnamed species versus the limited number of taxonomists available to describe them leaves little room to accelerate discoveries. Based on Scopus records, in the fields of taxonomy and phylogenetic systematics, I found that from the mid-1990s to early 2025, about 1600 papers were published either by Ecuadorians or by researchers affiliated with Ecuadorian institutions. This search included all organisms and viruses. For comparison, during the same period, Brazil's output was more than ten times higher. Of the total number of Ecuadorian publications, only 133 focused exclusively on naming new insect and spider taxa (genera and species), whereas in Brazil, taxonomic publications within this same research area exceeded 7000.

The publishing rate of Ecuadorian taxonomists increased from about 2.5 papers per year in the late 1990s and early 2000s to an average of eight documents per year in the past five years. In 2024, with about 12 publications, Ecuadorian authors reached their highest output, nearly half of which were about arachnids. A trend is clear, and it appears to be increasing, albeit slowly. Therefore, based on these data alone, insect (and spider) taxonomic research in Ecuador does not seem to be "in decline," but instead emerging. It is not my intention to provide a comprehensive analysis of the factors driving this trend. Several other variables could influence these results and provide a broader perspective. For instance, the total number of researchers and graduates in the country receiving salaries for their work, the availability of material (specimens and data) accessible to these researchers at any given time, among others.

Thus, a first obvious conclusion comes to mind: the taxonomic publishing output in Ecuador is vastly inferior than that of a more developed country such as Brazil. The reader may probably infer some explanatory reasons, and indeed, there are many. The absence offinancial support is certainly among the top. Our society lacks a sufficient number of qualified, well-paid taxonomists. In Latin America, this is even more concerning as large natural areas are being lost to give space for agriculture, cattle ranching, and other human development-rooted practices (29). Aside from the intrinsic economic and human health-driven interest by governments and private organizations to finance pest control, invasive species, and disease vectors research, there is nulle political will to fund insect taxonomy (30), for conservation purposes, for example. This is a science that underpins most other biological disciplines, including ecology, evolution, and conservation. Yet, the role it plays in understanding nature is rarely endorsed. Ironically, funding allocation to such human-related issues will not prevent us from fleeing the tragedy of losing biodiversity. Since every species has a function in complex ecological networks, which we barely understand for a few organisms, the loss of thousands of arthropod species (31) will inevitably lead to our decline. University authorities, as part of the Ecuadorian Academia, are among the leading players in this undervaluation of taxonomy. The reduction and almost complete absence of entomology-related positions, as well as the current slow-growing state of most national arthropod and invertebrate collections throughout the country, mirror this reality.

I am trying to understand why new generations of many enthusiastic and skilled students do not intend to put their hands to practice in this fundamental discipline. Is this a reflection of the current labor market in Ecuador, which favors other jobs that require expertise in microbial and zoonotic diseases or biosynthetic production? Or is it simply an inevitable trend emerging as a consequence of the onrush of new technologies and AI careers producing a mirage of opportunities aiming at “fast” economic gain? If this latter is the reason, or perhaps a combination of both or more factors, the result does not change: someone has to do the job; we need more brains to describe species.

Aside from the current disinterest, inadequate funding, and the unwillingness of Ecuadorian politicians and authorities to support insect science, it is up to us, the entomologists of today, to advocate for a new perspective in this vital field. We must inspire and guide current and future students to work with insects and other arthropods. Both private and state collections should be permanently open, offering easy and non-bureaucratic access to anyone conducting research. It should suffice to illustrate the astounding ecological roles these organisms play in ecosystems, but we must also advocate for the reopening and creation of new research positions. Our efforts should primarily focus on reaching students at the beginning of their undergraduate careers, or even those who are finishing high school. This strategy has been implemented in countries such as Brazil and Mexico for years. Entomology is a vibrant and dynamic field of study. Given its numerous benefits and potential to contribute to societal development, I believe a path toward its renaissance is not only possible but also well within reach. We must reflect on past mistakes and start addressing the necessary changes.

A message to future taxonomists

The taxonomic practice, like all human endeavors, requires discipline but above all, patience. Spending countless hours under the scope, identifying dozens of minute structures, dissecting and mounting internal organs, and illustrating and imaging them cannot be accomplished through shortcuts. Today’s artificial intelligence may be of help, but it is not the solution. Whether a “super AI” will one day take over this task for us remains to be seen. Several useful taxonomic tools have been previously published (32,33), and others are in development, leveraging the power of programming languages such as Python. Yet, these can only support what taxonomists do best: observe, compare, and describe. The ability to beautifully illustrate and analyze the form and the function is a human gift. Let’s use it to preserve what we still have.

It is our responsibility, new and old generations of taxonomists, to commit to the noble duty of naming organisms. The future may not look promising, and institutional government support may not be on our side. However, even under the most challenging

conditions, we have succeeded in publishing acceptable, well-crafted manuscripts. We will certainly keep up the pace.

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